HIGHLY RESILIENT MULTIFILAMENT YARN AND PRODUCTS MADE THEREFROM

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application claims the benefit of one or more prior filed applications: US provisional patent number 60/451307, filed 02/28/2003.

FIELD OF THE INVENTION

The present invention relates to a multifilament yarn comprising a low number of filaments in the yarn bundle. In particular, the present invention relates to a synthetic, low-filament number, continuous, multifilament yarn that is highly resilient and that is comfortable to a wearer of fabric including such yarn.

BACKGROUND

In the production of garments such as brassieres, foundation garments, and medical support garments, it is often necessary to provide reinforcement in specific areas of the garment. Such reinforcement enables a fabric and garments made from reinforced fabrics to provide desired support and comfort to a wearer. Typically, reinforcement is provided to fabrics by incorporating into the fabric a monofilament, synthetic, continuous filament yarn such as polyester or nylon. A monofilament yarn is generally preferred over a multifilament yarn because of the need for the superior resilience and recovery characteristics provided by a monofilament yarn. Monofilament yarns are also preferred because a yarn having increased resilience and recovery characteristics can be formed in a single filament of a nominal denier size in the yarn spinning process. The larger the denier of each individual filament utilized in a yarn, the greater the resilience of the total yarn bundle. Yet, generally, the larger denier sizes of monofilament yarn, such as deniers in the range of about 20 denier to about 100 denier, yield

higher resilience indices as compared to a same denier yarn made up of multiple, for example from 2 to 100, filaments. A monofilament yarn possess higher resilience properties than an equivalent denier multifilament yarn in almost every denier size commercially made.

Greater resilience monofilament yarns include long-chain synthetic polymers such as polypropylene, polyethylene, nylon, and polyester, which are used in many industrial and commercial applications. For example, higher denier, synthetic, continuous monofilament yarns having strength and superior resilience and recovery properties are utilized in fishing line, weed trimmer cutting lines, and sail rigging. Finer denier, such as 10, 15, 20, 30, 40, 50, 60, 70, 80 , and higher denier, monofilaments are used in textile and apparel applications for their resilience and recovery properties. Monofilament yarns are widely used in various methods of forming fabrics, including weaving, knitting, braiding, and the like. Higher resilience monofilaments are used in a variety of fabric constructions, particularly in weft-knitted and warp-knitted structures using various combinations of yarns. In some fabrics, a translucent, or sheer, effect is desired in certain stitches, for example in a weft-knit, mesh-effect pattern. A fine denier size monofilament is utilized for such translucent courses rather than a similar fine denier multifilament yarn, because a multifilament yarn, even one having a fine denier, would exhibit too much opacity and "coverage," thus losing the desired sheer effect.

While monofilament yarns can provide desirable resilience and visual characteristics to fabrics and garments, monofilaments possess a significant disadvantage. Cutting fabrics into various shaped parts or garment components can expose the severed ends of monofilament yarns all along the cut fabric edge. The severed yarn ends can be extremely difficult to cover or insulate from skin contact even with high quality sewing thread and seaming techniques. When a relatively large individual monofilament yarn protrudes out from a fabric surface or from a cut

fabric edge at a garment seam, the garment wearer often experiences skin irritation from the somewhat stiff, exposed monofilament yarn. Such irritation can lead to discomfort and eventual dissatisfaction with the garment. The problem of skin irritation from exposed monofilament yarns can be exacerbated in intimate apparel and/or medical use fabrics using higher denier monofilament yarns for increased fabric performance properties.

The problem of monofilament yarn skin irritation is well known, and has prevented the use of monofilament yarns when highly resilient yarn properties are desired to maximize function and performance of fabrics and garments. Thus, there is a need for a yarn that possesses high resistance to bending like a monofilament yarn while being acceptably comfortable to a garment wearer when in contact with the wearer's skin. The need for such a yarn includes a yarn that provides comfort both before and after a fabric comprising the yarn has been cut and sewn into a finished garment.

Multifilament yarns having a sufficiently high resilience and recovery index to satisfy the construction needs of certain engineered fabric structures are not commercially available. An example of a fabric structure in which a highly resilient multifilament yarn would be useful is a multi-layered, weft-knit spacer fabric. In a conventional multi-layered, weft-knit spacer fabric, the spacer yarn component is usually a monofilament yarn, selected to obtain the maximum obtainable composite fabric thickness and resilience. In such a spacer fabric, a monofilament yarn would essentially lie in a straight-line, vertical plane between and connecting the face layer and backing layer, maintaining the layers in a spaced relationship at a maximum fixed distance apart, and thereby resist bending. Accordingly, there is a need for a yarn in multi-layer spacer fabrics that includes the desirable properties of increased firmness, resilience, and recovery from

deformation characteristic of a higher denier monofilament yarn, while simultaneously solving the problem of the undesirable harshness of monofilament yarn against the skin.

Multifilament yarns have been previously disclosed. Intermingled, or twisted, multifilament yarns are disclosed by, for example, by U.S. Patent Nos. 5,442,903 to Lagarrigue, and 5,424,123 to Geirhos et al. The patent to Lagarrigue discloses a method of twisting heavy denier nylon or polyester monofilament yarns for industrial applications. Such applications include use as a reinforcement in tires, for paper machine junction felts, as a canopy support, and for heavy duty knitting or braiding. The Lagarrigue patent discloses assembling, twisting, and thermo-setting at least two filaments of synthetic material of a grist at least equal to 20 tex up to 500 tex (equivalent to 180 denier up to 4,500 denier) for textile operations.

The patent to Geirhos et al. discloses an intermingled multifilament yarn comprising primarily high modulus monofilaments made, for example, of aramid, carbon, or glass. The multifilament yarn has a total denier in a range between 700 dtex to 3000 dtex (630 denier to 2700 denier). High modulus yarns are often twisted together into multifilament yarns using an air intermingling process. The Geirhos et al. process teaches intermingling high modulus yarns at elevated temperatures, which tends to make the filaments brittle and break, leading to an appreciable reduction in tenacity of the filaments for each other.

Other patents disclose multi-layer warp knit and weft knit spacer fabric structures containing monofilament yarns. For example, U.S. Patent No. 6,116,059 to Rock et al. discloses an integrated, three-dimensional, warp-knitted spacer fabric, including a first fabric layer, a second fabric layer, and a resilient yarn interconnecting the two fabric layers. The first fabric layer is made from fiber rendered hydrophilic, and the second fabric layer is abrasion resistant. The Rock et al. patent discloses a monofilament yarn of between 40 denier and 150 denier in size

wherein the spacer pile yarn has sufficient resilience and stiffness to keep the first and second fabric layers apart even under the application of pressure.

U.S. Patent No. 5,735,145 to Pernick discloses an incontinence mattress pad made of a multiple layer, weft knit fabric. The multiple layer fabric is designed for absorbing moisture and wicking it from a first hydrophobic layer to a second hydrophilic layer by using highly efficient wicking spacer yarns of a preferably non-textured continuous, multifilament polyester. The multifilament spacer yarns preferably include 37 filaments, each filament having a denier in the range of 100 to about 200.

Multifilament yarns comprising a low number of individual monofilaments, each monofilament separately having a denier size that will not cause irritation to a wearer's skin and that possess high resilience and stiffness similar to that of a monofilament yarn have not been made available for apparel use.

Highly resilient, low-number filament, multifilament yarns, each monofilament separately having a high degree of resilience and a denier size that will not cause irritation to a wearer's skin, have not been used as spacer yarns in multi-layer, warp knit or weft knit composite fabrics to hold two fabric layers apart.

Thus, there is a need for a yarn that possesses high resistance to bending like a monofilament yarn while being acceptably comfortable to a garment wearer when in contact with the wearer's skin. The need for such a yarn includes a yarn that provides comfort both before and after a fabric comprising the yarn has been cut and sewn into a finished garment.

There is a need for a low filament number, multifilament yarn having a total denier size comparable to a high denier monofilament that includes only a few filaments, the finer denier of each individual filament of which would not irritate a wearer's skin.

There is a need for a yarn in multi-layer spacer fabrics that includes the desirable properties of increased firmness, resilience, and recovery from deformation characteristic of a higher denier monofilament yarn, while simultaneously solving the problem of the undesirable harshness of monofilament yarn against the skin.

There is a need for such a highly resilient, low filament number, multifilament yarn bundle that avoids the irritation associated with exposure to stiff monofilaments and that can be used in both weft-knitted and warp-knitted fabric structures and in either single or double needle knitting systems.

There is a need for a single knit fabric structure utilizing a low filament number, multifilament, highly resilient yarn that can be made in a conventional single needle system of weft knitting on cylinder needles.

There is a need for a sheer fabric knit in a conventional multi-bar warp knit on a single needle bar warp knit Tricot or Raschel machine utilizing a low filament number, continuous multifilament, synthetic yarn having both resilience and a fine denier.

SUMMARY OF THE INVENTION

The present invention comprises a multifilament yarn that comprises a low number of filaments in the yarn bundle and that is highly resilient. Embodiments of the present invention comprise a synthetic, low filament number, continuous, multifilament yarn that is highly resilient and that is comfortable to a wearer of such yarn.

Low-filament number, continuous, multifilament yarns of the present invention have a high resistance to deformation and bending similar to a monofilament yarn. Such highly resilient multifilament yarns can be utilized in various fabric constructions and garments made therefrom. Embodiments of the present invention include articles of manufacture, for example clothing,

apparel, and medical garments, produced from fabrics containing such a yarn. Garments made from such multifilament yarns avoid exposure of a wearer's skin to irritating monofilament yarns and cut ends of monofilament yarns and thus provide garment wearing satisfaction and comfort not available with garments containing monofilament yarns.

The present invention provides embodiments of various yarn deniers and filament counts having advantageous performance properties. Embodiments of the present invention provide a highly resilient, multifilament yarn that can be utilized in both weft-knitted and warp-knitted fabric structures and in either single or double needle knitting systems. Accordingly, a highly resilient, a low filament number, multifilament yarn of the present invention can be used to produce a multi-layer, weft knit spacer fabric, a multi-layer, warp knit spacer fabric, a single layer, warp knit fabric, and/or a single layer, weft knit fabric. Such a highly resilient, low filament number, multifilament yarn bundle provides desired characteristics of stiffness and resistance to bending without being an uncomfortable irritant against the skin of a person wearing a garment made with such fabrics.

In one aspect of the present invention, embodiments comprise a multifilament yarn having a very few continuous filaments that are highly resilient. The filaments are either twisted or intermingled to facilitate maintaining the individual filaments sufficiently in the yarn bundle. Such twisting or intermingling helps the yarn to maintain a bundle integrity suitable for forming fabric in weft-knitted and/or warp-knitted fabric constructions. In embodiments in which the multiple filaments are "up-twisted," the higher the number of turns, or 360 degree twists, that are imparted in each inch length of yarn, the more resilient the resulting yarn becomes, and the greater its stiffness, or resistance to bending.

In another aspect of the present invention, a low filament number, multifilament yarn having a total denier size comparable to a high denier monofilament includes only a few filaments such that the finer denier of each individual filament would not irritate a wearer's skin.

In yet another aspect of the present invention, a highly resilient, low filament number multifilament, continuous, synthetic yarn comprises a spacer yarn in a multi-layer weft knit fabric. The multi-layer fabric can be made using both dial and cylinder needle beds. The composite fabric has two discrete knit fabric layers that are secured in a substantially parallel and spaced apart relationship. A plurality of the resilient spacer yarns extend between the two fabric layers and secure the two fabric layers in a substantially uniformly spaced apart manner. The two fabric layers may be formed using a combination of stitches, such as knit, miss, and/or tuck stitches.

In an embodiment, a multi-layer weft knit fabric includes two parallel knit fabric layers, at least one of the fabric layers having an integrally knitted decorative Jacquard design. The Jacquard design can use one or more patterns, such as geometric, free-form, floral, abstract, brand logos, and the like on the outer, technical face surface of the fabric layer. The other layer can include either a decorative design effect on the outer, technical face surface or a less decorative construction. The two fabric layers are joined together by a series of knit or laid-in courses utilizing a highly resilient, low filament number, multifilament yarn forming spacer yarns. The spacer yarns secure the two layers together in a spaced apart relationship relative to each other. The Jacquard design may be formed using a combination of stitches, including knit, miss, and/or tuck stitches. Similarly, the less decorative fabric layer construction may be formed using a combination of stitches including knit, miss, and/or tuck stitches.

In another embodiment, a fabric formed on a single needle bed of a circular or flat weft knitting machine comprises a highly resilient, low filament number, multifilament yarn. Such a process can produce a single knit fabric structure in which the multifilament yarn can be used as a ground yarn and/or can provide a visual effect, such as a sheer quality to the fabric. Because such a fabric is single knit, the resilient multifilament yarn provides a non-irritating surface for contact with the skin of the wearer of a garment made from the fabric.

In other embodiments, a fabric formed on a multi-guide bar warp knitting machine having either a single-needle bar or double-needle bar comprises a highly resilient, low filament number, multifilament yarn. For example, in a fabric produced on a single-needle bar warp knit Tricot or Raschel machine, the resilient multifilament yarn can be combined with an elastomeric yarn such as spandex to function as a ground yarn or as a visual effect yarn. Use of such a yarn can provide a desired sheerness, as well as resilience, to the fabric construction, while simultaneously avoiding stiff monofilament yarn irritation to a wearer's skin. In a multi-layer, warp knit fabric produced on a double-needle bar machine, the resilient multifilament yarn can be utilized as a spacer yarn between layers of fabric.

In another embodiment, a multi-layer weft knit fabric includes two discrete knit fabric layers comprising continuous, multifilament, synthetic yarns. The multifilament yarns can be flat or textured and have a denier in a range of about 20-300, preferably about 30-150 denier in size. The multifilament yarns can include spandex yarns in a range of about 20-70 denier. The spacer courses between the two layers comprise highly resilient, continuous, low filament number multifilament yarns in a range of about 20-150 denier in size. The highly, or substantially totally, resilient, continuous, low filament number multifilament spacer yarns

comprise polyester or nylon yarn in a range of about 40-100 total denier in size. The multifilament spacer yarns comprise individual filaments that have a denier in a range of about 3-10 denier per filament.

Any of the conventional synthetic polymer fibers may be utilized to produce a highly resilient, low filament number, multifilament yarn of the present invention. For example, thermally heat-settable, synthetic, continuous filaments produced from nylon, polyester, and/or blends thereof may be used to produce multifilament yarns according to the present invention.

Multifilament yarns according to the present invention can be twisted or intermingled to produce, for example, 20/2, 20/4, 30/6, 40/8, 50/10, 60/12, 70/8, 80/10, and 100/12 yarns, formed using conventional up-twisting or intermingling methods and techniques. Twisting or intermingling filaments provides additional qualities of resilience and stiffness that achieve desired performance characteristics in engineered fabrics. Yet, using individual filaments in the multifilament bundle each having a fine denier allows a resulting yarn and fabrics and garments including such yarns to be non-irritating to a wearer's skin, even when exposed to cut ends of the yarns.

In embodiments of the present invention, polyester and/or nylon continuous, low filament number, multifilament yarns advantageously provide heat setting properties that allow fabrics made with such yarns to be heat-molded to a desired form and shape. For example, polyester and/or nylon multifilament yarns according to the present invention can be utilized in single knitted weft or warp knit constructions, as spacer yarns in multi-layer weft knit or warp knit fabrics, and as a molded breast cup in a brassiere garment.

In the present invention, embodiments include methods of making low filament number, multifilament yarns and fabrics comprising such yarns as described above.

Features of a highly resilient multifilament yarn and products made therefrom of the present invention may be accomplished singularly, or in combination, in one or more of the embodiments of the present invention. As will be appreciated by those of ordinary skill in the art, the present invention has wide utility in a number of applications as illustrated by the variety of features and advantages discussed below.

A highly resilient, multifilament yarn, and products made therefrom, of the present invention provide numerous advantages over prior yarns and textile products. For example, the present invention advantageously provides a multifilament yarn that comprises a low number of filaments in the yarn bundle and that is highly resilient. Such resilience allows yarns of the present invention to resist deformation and bending similar to a monofilament yarn.

Another advantage is that the present invention provides a low filament number, multifilament yarn having a total denier size comparable to a high denier monofilament yarn such that the finer denier of each individual filament would not irritate a wearer's skin. As such, the present invention advantageously provides a multifilament yarn that is highly resilient and that is comfortable to a wearer of such yarn, particularly around seams where fabric is cut and the fabric edges are sewn into garments.

Another advantage is that the present invention provides a highly resilient multifilament yarn that can be utilized in various fabric constructions. Highly resilient and non-irritating yarns of the present invention can be used in both weft-knitted and warp-knitted fabric structures and in either single or double needle knitting systems. Yarns of the present invention can be advantageously utilized as spacer yarns in either weft-knit or warp-knit multi-layer fabrics, and for producing visual effects such as sheerness or Tricot or Raschel-made patterns.

Another advantage is that the present invention provides highly resilient, non-irritating, multifilament yarns that may be utilized in garments, such as clothing, apparel, and medical garments, that allow wearer satisfaction and comfort not available with garments containing monofilament yarns.

As will be realized by those of skill in the art, many different embodiments of a highly resilient multifilament yarn, and products made therefrom, according to the present invention are possible. Additional uses, objects, advantages, and novel features of the invention are set forth in the detailed description that follows and will become more apparent to those skilled in the art upon examination of the following description and drawings, or by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a multifilament yarn in an embodiment of the present invention.

FIG. 2 is a perspective view of another multifilament yarn in an embodiment of the present invention.

FIG. 3 is a cross-sectional view of a weft knit, multi-layer spacer fabric in an embodiment of the present invention.

FIG. 4 is a diagram of a weft knitting sequence used in forming a decorative Jacquard design on a fabric face layer of the multi-layer spacer fabric in FIG. 3 in an embodiment using a multifilament yarn according to the present invention.

FIG. 5 is a diagram of another weft knitting sequence used in forming a substantially less decorative face of a multi-layer spacer fabric in an embodiment using a multifilament yarn according to the present invention.

FIG. 6 is a diagram of a warp knitting construction stitch diagram for forming a multi-layer spacer fabric in an embodiment using a multifilament yarn according to the present invention.

FIG. 7 is a diagram of another warp knitting construction stitch diagram for forming a conventional single layer fabric in an embodiment using a multifilament yarn according to the present invention.

FIG. 8 is a knitting diagram for using a multifilament yarn according to the present invention.

FIG. 9 illustrates a brassiere intimate apparel garment utilizing fabric as depicted in FIG. 4 comprising a multifilament yarn in an embodiment of the present invention.

FIG. 10 shows a cross-section of the brassiere cup in FIG. 9 detailing a multifilament yarn in an embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE PRESENT INVENTION

In the following description, like reference characters designate like or corresponding parts throughout the several views. Also in the following description, it is to be understood that such terms as "forward," "rearward," "front," "back," "right," "left," "upwardly," "downwardly," and the like are words of convenience and are not to be construed as limiting terms. Referring now to the drawings in general, the illustrations are for the purpose of describing a preferred embodiment of the invention and are not intended to limit the invention thereto.

Figures 1-10 show embodiments of a highly resilient, non-irritating, multifilament yarn of the present invention and products made from such yarns. Referring to Fig. 1, a yarn according to one embodiment of the present invention includes a low number of individual monofilaments 6. The monofilaments 6 are combined together by up-twisting the individual monofilaments together using either an S-twist or Z twist direction with a significant number of 360 degree turns per inch of yarn length. In Fig. 1, the yarn a 20 denier continuous filament, synthetic nylon or polyester yarn. The yarn includes 4 individual monofilaments, each a highly

resilient filament having a denier size of 5. Such a yarn can also be formed using as few as 2 individual filaments, for example a 20 denier, 2 filament yarn, designated as 20/2 (20 denier/2 filaments).

In the embodiment in FIG. 1, the yarn has a twist of 10 to 16 minimum turns per inch along the length of the yarn. In other embodiments, a yarn according to the present invention can have as few as one or two twists per centimeter or inch of yarn length. The 20 denier, 4 filament yarn as illustrated in FIG. 1 can be air entangled as in FIG. 2, instead of twisted as shown in FIG.1. In embodiments, the filaments may be air entangled with as few as 2 entanglement nodes per meter of length and as many as up to 8, 10, 12, or 14 entanglement nodes per meter of yarn length. The dynamics of twisting individual fibers or filaments into a composite yarn can produce varied degrees of stiffness and stability depending on the number of turns per inch of twist that are induced. In general, as the number of turns per inch are increased, the stiffness index and resilience, or resistance to bending, characteristics of the yarn increase proportionally. A yarn such as that illustrated in Fig. 1 would impart superior resilience properties when incorporated into a knitted fabric structure. In addition, such a yarn soft to the touch after it has been severed by fabric cut and sew operations during garment manufacturing, and thus would not be irritating against the skin of the garment wearer.

As shown in Fig. 2, a low number of individual monofilaments 8, are combined together using conventional intermingling techniques such as heated-air entanglement to form the total composite yarn. The yarn as illustrated comprises a continuous filament synthetic nylon or polyester yarn of about 70-72 denier. The yarn includes 8 individual monofilaments, each a highly resilient filament having a denier size of 9.

Fig. 3 is a cross-sectional view cut parallel to the course-wise or weft direction of a multi-layered weft knit, spacer fabric. Fabric 10 contains a yarn according to the present invention, and includes a first layer 12. Layer 12 can be either a substantially decorative Jacquard pattern design or a substantially less decorative non-Jacquard face. A second layer 14 is a substantially less decorative design. A plurality of spacer yarns 16 are secured within each of the respective knit fabric layers 12, 14, to maintain and secure each of the respective layers 12, 14 in a spaced-apart relationship relative to each other. A space 18 is created between the first discrete fabric layer 12 and the second discrete fabric layer 14. Spacer yarns 16 can be either of the yarns shown in the embodiments in Fig. 1 and Fig. 2. The spacer yarns 16 are selected for their optimum resilience to bending related to denier and filament count. The spacer yarns 16 will maintain the first and second discrete fabric layers 12, 14 in a spaced-apart relationship and as a unified composite fabric when subjected to stretching or to a heat molding process.

In a preferred embodiment, the yarns forming the first discrete knitted layer 12, i.e. the substantially decorative surfaced Jacquard design pattern, are synthetic, continuous filament yarns such as those made from polymers such as nylon or polyester, or blends thereof, or the like. The yarns are desirably 20-200 denier multifilament nylon or polyester yarns, 10-70 denier spandex yarns, 18/1's – 60/1's spun equivalent nylon, polyester, or cotton count, or blends or combinations thereof. Particularly preferred are combinations of textured multifilament semi-dull or matte luster yarns, spun yarns, and flat non textured bright cross-section luster multifilament yarns as the resultant extreme differences between the lusters of such yarns serve to accentuate the contrast between the pattern design motif and the surrounding ground knit areas.

Elastomeric spandex yarns are integral to the fabric construction creating the desired amount of stretch needed for the end use application, and are heat thermo-settable for any subsequent post-molding process such as brassiere cups for example, as well as the recovery of the fabric from the amount of stretch imparted, and the spandex recovery force serves to enhance the spacer fabric composite thickness by enabling it to maintain the desired spaced relationship of the first and second discrete fabric layers. The second discrete fabric layer 14, i.e. the substantially less decorative back or lining layer of the multi-layer spacer fabric is desirably knit from the same yarns as described for the first discrete fabric layer, and can either have a substantially fancy and decorative outer surface or one that is formed using a combination of stitches selected from a group consisting of simple knit, miss, or tuck. In a preferred fabric end use application, as described in FIG. 4 and FIG. 5, for example, the multi-layer weft knit spacer fabric is the primary substrate used as a molded breast cup for a brassiere, a desirable yarn selection for this fabric layer would be one of a relatively soft to the touch fine filament yarn, preferably textured, and resulting in comfort against the skin of the wearer. Yarns created under the embodiments of the present invention may also be used in fabric layer 12 in order to facilitate a decorative effect whereby a combination of a essentially heavier denier continuous multifilament synthetic yarn such as flat or textured nylon or polyester in contrast to a finer, more transparent yarn of low filament count according to the present invention, taking full advantage of the comfort properties afforded by embodiments of the present invention instead of choosing a clear or semi-dull monofilament fine denier yarn as would normally be used by those skilled in the art.

The spacer yarns 16 preferably comprise substantially resilient continuous low multifilament yarns in a range of 20 denier-150 denier in size, or, more preferably substantially

resilient continuous low multifilament polyester or nylon yarn in a range of 40 –100 total denier in size, and comprised of individual filaments that are in a range from 3 denier-10 denier per each filament. The yarns are described as desirably in a range of 70-300 denier continuous multifilament yarns such as polyester or nylon, or a monofilament polyester or nylon yarn in a size range of 20-80 denier. A multifilament yarn is also preferred over a monofilament yarn, for example, as in the case of heat molding to form a shaped breast cup component of a brassiere, and the fabric stretches to conform to the mold shape, a sufficient population of multi-filament yarns in the spacer yarn 16 assures that the spacer composite does not sheer out and lose the desirable opacity in appearance of the finished molded cup part, and the subsequent finished brassiere garment.

FIGS. 4 and 5 illustrate embodiments of a method of producing the fabric 10. FIG. 4 illustrates a design pattern repeat for forming a Jacquard patterned design spacer fabric according to the present invention, with the dial and cylinder needles of the knitting machine being arranged in a standard or rib gaiting. In this rib-gaited method, the sequence of knitting uses essentially all needles of the cylinder and dial in forming the spacer connections except when the spacer yarn becomes involved with those particular needles of the cylinder whereby the Jacquard selected needles are tucking on specific cylinder needles according to the desired pattern design using Feed 3 and Feed 6. Feed 1 of the sequence illustrates the yarn 28 as it is fed in a reciprocating manner between the dial and cylinder needle beds only to every other needle of each bed; this yarn 28 will form the spacer yarns 16 in the fabric 10. Feed 2 forms the first discrete fabric layer on all needles of the dial from spandex yarns 32 that are plaited along with textured synthetic multifilament yarns 30, forming layer 14 in fabric 10. Feed 3 forms the first discrete fabric layer on the all cylinder needles incorporating the Jacquard design on the

technical face through selection of knit or tuck stitches (taking care never to tuck on the same needle that the previous spacer yarn from Feed 1 was inlay tucked on due to the necessity for holding down the inlayed tuck spacer yarn on that needle with a subsequent knit stitch so as to keep it from rising up and moving out off the desired position to facilitate the exact knitting sequence and spacer yarn positioning) using the spandex yarn 32 plaited with flat bright luster synthetic multifilament yarn 34, forming Jacquard selected decorative layer 12 in fabric 10. Feed 4 illustrates the spacer yarn 28 as it is fed in a reciprocating manner between the dial and cylinder needle beds to the alternate needles that were not fed yarn from feed 1, and forms spacer yarns 16 in fabric 10. Feed 5 just like Feed 2 forms the second discrete fabric layer on all needles of the dial from spandex yarns 32 plaited along with textured synthetic multifilament yarns 30. Feed 6 forms the first discrete fabric layer on all cylinder needles incorporating the Jacquard design on the technical face through selection of knit or tuck stitches (and, just as in the case of Feed 3, taking care never to tuck on the same needle that the previous spacer yarn from Feed 4 was inlay tucked on due to the necessity for holding down the inlayed tuck spacer yarn on that needle with a subsequent knit stitch so as to keep it from rising up and moving out off the desired position to facilitate the exact knitting sequence and spacer yarn positioning) using the spandex yarn 32 plaited with flat bright luster synthetic multifilament yarn 34, forming layer 12 in fabric 10.

FIG 5. illustrates a method of knitting a less decorative non-Jacquard design weft knit spacer fabric that is essentially plain fabric 10 according to the present invention with needles of the knitting machine arranged in an interlock gaiting, that is, all needles of the dial are directly opposite to and lined up with all needles of the cylinder in this alternate method the sequence of knitting essentially uses all needles of both the dial and cylinder for forming the spacer

connections. Feed 1 of the sequence illustrates a low multifilament highly resilient spacer yarn of the present invention 54 as it is fed in a reciprocating manner between the dial and cylinder needle beds to essentially inlay tuck on every other or alternate needles of both needle beds. This yarn 54 will form the spacer yarns 16 in fabric 10. Feed 2 forms the second discrete fabric layer on alternate dial needles from spandex yarn 58 that is plaited along with flat or textured synthetic multifilament yarn 56, forming layer 14 in fabric 10. Feed 3 also forms the second discrete fabric layer on alternate dial needles missed by Feed 2 and completes the continuous course of knitted jersey of the second discrete fabric layer 14 on the dial using spandex yarns 58 plaited along with textured continuous multifilament yarn 60. Feed 4 knits on alternate needles of the cylinder using spandex yarns 58 plaited along with flat or textured continuous multifilament yarn 60 forming the non-Jacquard design less decorative first discrete fabric layer 12 of fabric 10. Feed 5 also forms the first discrete fabric layer on alternate needles of the cylinder missed by Feed 4 and completes the continuous course of knitted jersey of the first discrete fabric layer on the cylinder using spandex yarns 58 plaited along with flat or textured continuous multifilament yarn 60. Feed 6, like Feed 1, illustrates a low multifilament highly resilient spacer yarn of the present invention 54 as it is fed in a reciprocating manner between the dial and cylinder needle beds to essentially inlay tuck on the alternate needles missed by Feed 1. This yarn 54 will form the spacer yarns 16 in fabric 10. Feed 7, like feed 2, forms the second discrete fabric layer on alternate dial needles from spandex yarn 58 that is plaited along with flat or textured synthetic multifilament yarn 56, forming layer 12 in fabric 10. Feed 8, like feed 3, also forms the second discrete fabric layer on alternate dial needles missed by Feed 7 and completes the continuous course of knitted jersey of the second discrete fabric layer 14 on the dial using spandex yarns 58 plaited along with textured continuous multifilament yarn 60. Feed 9, like Feed 4, knits on

alternate needles of the cylinder using spandex yarns 58 plaited along with flat or textured continuous multifilament yarn 60 forming the non-Jacquard design less decorative first discrete fabric layer 12 of fabric 10. Feed 10, like Feed 5 forms the first discrete fabric layer on alternate needles of the cylinder missed by Feed 9 and completes the continuous course of knitted jersey of the first discrete fabric layer on the cylinder using spandex yarns 58 plaited along with flat or textured continuous multifilament yarn 60.

FIG 6. illustrates an alternate method of forming a spacer fabric on a warp knit machine having two needle bars and at least four guide bars. Two discrete fabric layers are formed separately on each of a front (F) and back (B) needle bar that are supplied yarn from 4 individual guide bars. In this example, BAR 1 is solid threaded with a bright luster 40 denier, 30 filament continuous multifilament yarn 61. Two discrete fabric layers are formed by alternately knitting back needle bar (B) only with yarns 61 fed from BAR 1. On the first course of a 4 course repeat as stitch notation 0-0/1-3/3-3/2-0//, BAR 1 moves 0-0 and misses any overlapping of needles on the front needle bar (F), while an overlapping movement from space positions 1 to 3 on the back needle bar ("double-needle overlap") (1-3) knits on the back needle bar only, missing the front needle bar by again not overlapping (3-3), and knitting again on the back needle bar (B) as 2-0. Thus BAR 1 forms a first discrete fabric layer on the back (B) needle bar only. BAR 4, with stitch notation as shown 2-0/0-0/1-3/3-3// only knits on the front needle bar and is solid threaded with a semi-dull luster 40 denier, 20 filament yarn 65. BAR 4 knits 2-0 (double needle overlap) on the front needle bar; misses the back needle bar (0-0); again knits on the front (F) needle bar only (1-3); and misses overlapping back the back needle bar (B) with a 3-3 instruction. BAR 2 and BAR 3 alternately knit on both the front (F) and back (B) needle bars with stitch notation 1-0/1-2/2-3/2-1// feeding 20 denier, 4 filament spacer yarn 63 of the present invention connecting

both of the first and second discrete fabric layers formed on the back and front needle bars and serving as the spacer yarn securing said first and second discrete fabric layers in a parallel and spaced relationship with each other. BAR 2 and BAR 3 are knitting exactly alike on all courses of both back and front needle bars and serve so as to result in a 40 denier, 8 filament single end result.

FIG. 7 illustrates a lap diagram of a sheer control single layer warp knitted fabric formed using 2 guide bars of a standard multi-guide bar single needle bar Raschel machine and utilizes a yarn according to an embodiment of the present invention. BAR 1 is solid threaded using 20 denier, 4 filament continuous multifilament synthetic yarn shown as 69 and knits in a 0-2/2-0/4-2/2-4// stitch pattern notation. Guide BAR 2 is solid threaded with a spandex yarn of 210 denier shown as 70, and lays-in a 0-0/2-2/0-0/4-4// stitch pattern notation. The resultant fabric is one having excellent high power and support properties while possessing a sheerness due to the relatively fine 20 denier used. Use of a 15 or 20 denier monofilament continuous synthetic yarn would satisfy the requirement for sheerness and resilience of fabric, however the monofilament ingredient would pose an irritation source after fabric is cut and sewn into an intimate apparel figure control garment and the severed ends of the 15 or 20 denier monofilament yarns can ultimately come in contact with the skin of the garment wearer. A 20 denier, 4 filament yarn according to an embodiment of the present invention would fully satisfy such fabric requirements without the monofilament irritation problem.

FIG. 8 illustrates an alternative application of a yarn according to the present invention and as used as a styling tool in a single layer weft knit fabric. As shown in FIG. 8, a pointelle mesh is created using essentially transparent fine denier low multifilament yarn.

FIG. 9 illustrates a brassiere 64, generally representative of an intimate apparel garment, utilizing a fabric according to one embodiment of the present invention as illustrated and described in FIGS. 3 and 4. The weft knit spacer Jacquard design patterned outer face fabric composite 10 is shown as used for the cup portions 66, and at once serves as the outer decorative fabric, the spaced middle layer, and the inner fabric layer, all in one stretchable, heat moldable composite fabric, instead of the garment manufacturer having to combine three or more different and separate components consisting of a decorative stylish outer face fabric, a middle layer of shaped foam or fiberfill padding, and a functional inner fabric lining layer.

FIG. 10 illustrates a cross-sectional view of the brassiere 64 as viewed in Fig. 9, showing an embodiment of the present invention in an exemplary use as the brassiere breast cup component which serves to provide; an outer decorative faced fabric layer 66 which is described as 12 of fabric 10 from FIGS. 3 and 4, and as viewed from the face of the garment, a spacer middle layer comprised of spacer yarns 16 forming spaced thickness area 18 as in FIG. 3, and a discrete inner cup lining fabric layer 14, which at once completes the brassiere cup construction in one unified integrally knitted weft knit spacer fabric composite thereby minimizing the number of steps in the garment manufacturing process by providing one multifunctional fabric substrate instead the use of three or more individual components for construction of the brassiere cup. The highly resilient spacer yarns 16 are embodiments of the present invention as illustrated in FIG. 1 and FIG. 2.

Although the present invention has been described with reference to particular embodiments, it should be recognized that these embodiments are merely illustrative of the principles of the present invention. Those of ordinary skill in the art will appreciate that a highly resilient multifilament yarn and products made therefrom of the present invention may be

constructed and implemented in other ways and embodiments. Accordingly, the description herein should not be read as limiting the present invention, as other embodiments also fall within the scope of the present invention.

Certain modifications and improvements will occur to those skilled in the art upon a reading of the foregoing description. By way of example, a variety of fabrics may be constructed using the yarn, a variety of garments may be constructed from fabrics made using the yarn, and the like, all according to the present invention as illustrated by the description set forth hereinabove. All modifications and improvements have been deleted herein for the sake of conciseness and readability but are properly within the scope of the following claims.